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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2017

Course Code: CH303
Course Name: MASS TRANSFER OPERATIONS –I (CH)

Max. Marks: 100 Duration: 3 Hours

Any missing data may suitably be assumed.
Psychrometric chart is permitted. Heat and Mass transfer data book is permitted.
Graph Sheets will be supplied.

PART A

Answer any two full questions, each carries 20 marks.

1 a) Derive Reynolds analogy between heat, mass and momentum transfer. (5)

b) Explain the following with reference to plate columns: (a) Flooding (b) Weeping (c) coning (d) Dumping and (e) turndown ratio (f) entrainment (g) priming (7)

c) Explain pseudo-steady-state diffusion of A through stagnant B. Derive the necessary relation for experimental determination of diffusivity by Winkelmann's method. (8)

2 a) State and explain Fick's law of molecular diffusion and derive Fick's second law of diffusion. (5)

b) What are the general principles underlying the film, penetration and surface renewal theories for mass transfer across phase boundaries? (5)

c) Compare the various kinds of trays used and also sketch them. (10)

3 a) Oxygen is diffusing through carbon dioxide under steady-state condition, with CO_2 non-diffusing at temperature 293 K and pressure 101.3 kPa. The partial pressure of oxygen at two planes 4 mm apart are 15 kPa and 7.5 kPa. The diffusivity of oxygen in CO_2 is 1.53×10^{-5} m^2/s. Calculate the rate of diffusion per unit area of the planes. (5)

b) Starting from the Fick's law of diffusion, derive an equation to calculate the rate of mass transfer for diffusion of A through stagnant B. (5)

c) Explain gas phase and liquid phase controlled systems in mass transfer. (5)

d) Explain the use of venturi scrubber with a neat sketch. (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Explain Murphree plate efficiency. Substantiate the statement that Murphree plate efficiencies can even exceed 100%. (5)

b) A batch of water containing 15 ppm residual chlorine is to be treated with activated carbon to reduce the chlorine concentration to 0.5 ppm. The equilibrium distribution coefficient is C/X = 0.80 where C is in kg Cl_2/m^3 liquid and X is the adsorbate loading in kg Cl_2/kg carbon. Calculate the minimum mass of carbon/unit volume of water which can be used. (10)

5 a) Hydrogen sulphide is to be removed from a mixture of hydrogen sulphide and methane using monoethanolamine as solvent. The feed gas containing 20% H_2S is admitted to a plate absorber at a rate of 2000 m^3/h at 303 K and 101.3 kPa. The equilibrium relation y = 1.1x is found to be applicable in the concentration range of interest. The solvent enters the column free of H_2S at a rate 1.2 times the (10)

minimum. If it is desired to remove 90% of the sulphide from the gas, determine: (a) Minimum solvent flow rate, kmol/h and (b) The number of theoretical plates using Kremser equation.

b) Air with a dew-point of 294 K and a percent humidity of 40% enters a dehumidifier and leaves at 287 K with a dew point of 285 K. How much water is removed per kg dry air? How much heat is removed per kg dry air? Solve using psychrometric chart. (5)

6 a) Ammonia is to be removed from a 10% ammonia-air mixture by absorbing in water. The absorber is operated at 101.3 kPa and treats 300 kg/h of the gas entering the column and recover 95% of the ammonia. The water used is 20% more than the minimum required. Overall stage efficiency is 70%. Operation is assumed to take place isothermally. The equilibrium partial pressure for ammonia solution at the operating temperature is given below: (10)

$\bar{P}_{NH_3}, kPa$	1.6	2.4	4.3	6.7	9.3
$kg\ NH_3/100\ kg\ water$	2	3	5	7.5	10

Determine (a) The minimum water rate, kg/h (b) The number of actual plates.

b) Bring out clearly the difference between adiabatic saturation temperature and wet bulb temperature. Show that they are nearly same for air-water system. (5)

PART C

Answer any two full questions, each carries 15 marks.

7 a) Distinguish between the unit operations drying and evaporation. (5)

b) 1000 kg of an aqueous solution of Na_2CO_3 containing 15% carbonate by weight is fed to a crystalliser. 80% of the carbonate is recovered as $Na_2CO_3.10H_2O$ by evaporation of water and subsequent cooling to 278 K. The solubility of Na_2CO_3 at 278 K is 9.0% (weight). Determine: (a) The quantity of crystals formed (b) The amount of water evaporated. (10)

8 a) A batch of granular solids containing 30% moisture is to be dried in a tray dryer to 15 % moisture by passing a stream of air across its surface. If the constant rate of drying under these conditions is 2.5 kg/m^2h and the critical moisture content is 15%, calculate the drying time. Assume the drying surface to be 0.03 m^2/kg dry solid. All moisture content is on wet basis. (10)

b) With the help of a neat sketch explain the working of a forced circulation crystalliser. (5)

9 a) Discuss the difference between falling rate and constant rate regimes in drying. (5)

b) What is the reason for caking of crystals and explain the methods to prevent it (5)

c) As an application of ΔL law of crystal growth discuss how to predict the product size distribution from seed crystals size distribution. (5)

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